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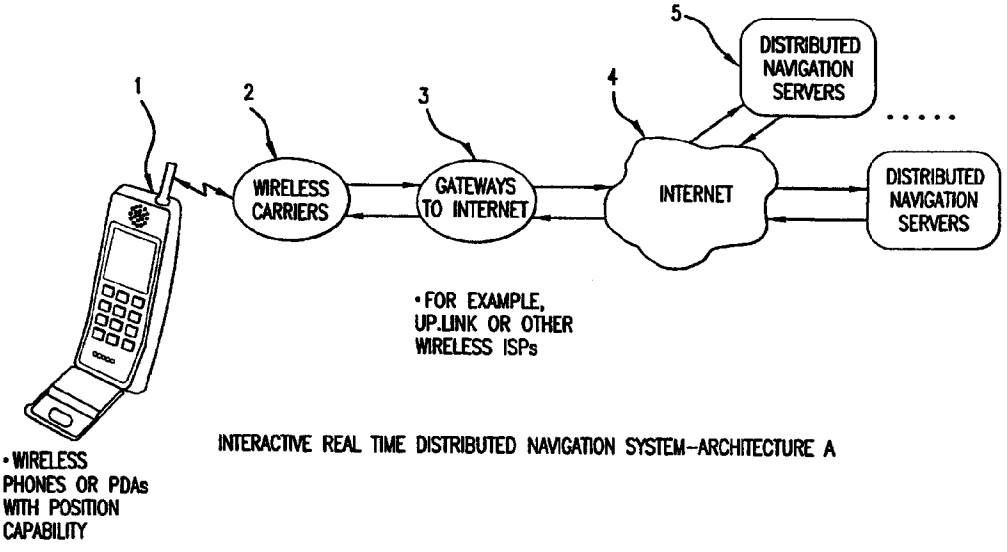
(54) Title: METHOD AND SYSTEM FOR A REAL-TIME DISTRIBUTED NAVIGATION SYSTEM



INTERACTIVE REAL TIME DISTRIBUTED NAVIGATION SYSTEM–ARCHITECTURE A

(57) Abstract: An interactive real-time distributed navigation system (1) is disclosed. In the present invention a user's location is determined by generating a position signal at the user's location. Through wireless communication (2) between the user and distributed navigation servers (5), the user is presented with a list of candidate locations. The user's choice from the candidate list is then used by the navigation servers (5) to obtain an accurate measurement of the user's location. Having established a user's location, the system (1) proceeds to provide navigational prompts to the user to reach a final destination.

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METHOD AND SYSTEM FOR A REAL-TIME DISTRIBUTED NAVIGATION SYSTEM

I. Field of Invention

This invention relates to navigation systems and location based information delivery. Specifically, this invention provides means for delivering interactive and real time navigation information using distributed navigation information processing systems.

II. Background of Invention

Currently, the most advanced navigation systems are largely based upon global positioning system (GPS) devices which have been applied in automobile navigation systems, see, e.g., U.S. Patent Nos. 5,938,720, 5,928,307, 5,922,042, 5,912,635, 5,910,177, 5,904,728, 5,902,350, all incorporated herein by reference for all purposes. Such automobile navigation systems, however, are expensive and inconvenient to use. Therefore, there is a great need in the art to incorporate navigation systems in personal data assistant, cellular phone or other small handheld electronic devices.

However, there are several technical obstacles that prevent the incorporation of navigation capabilities in handheld devices for providing turn-to-turn real time navigation services. One such obstacle is the amount of geographic data needed to provide reasonable detailed navigation information. In the existing automobile navigation systems, the GPS system is employed to provide location and movement information about a user. Geographic information is usually stored in a geographic mapping database stored in the CD-ROM or a hard-disk drive device. In a small (handheld) device, such as a cellular phone, however, the amount of embedded

memory is limited and is impractical to store the large amount of geographic information.

Another obstacle is that the lack of information processing power of small devices such as a cellular phones. The information processing power of a cell phone is usually provided by an embedded microprocessor with limited memory. While the information processing power of embedded microprocessors is generally increasing, those processors are still not suitable for processing CPU intensive real time navigation.

An additional obstacle is that the location accuracy provided by current technology, either Enhanced GPS based (SNAPTRACK), network based system (TRUEPOINT). The inaccuracy of the GPS based systems is either imposed by the U.S. Department of Defense (Selective Availability or S/A) or due to atmospheric and timing errors limiting the accuracy of a single GPS receiver to +/- 50 meters. There are methods which can be use to enhance accuracies to +/- 5 meters. These methods use a known position, such as a surveyed control point, as a reference point to correct the GPS position error. These methods of correcting GPS positions are referred to as Differential GPS or DGPS. The DGPS corrections can be applied to the GPS data in real-time using data telemetry (radio modems). The U.S.A. and Canadian Coast Guard are establishing a series of radio beacons to transmit the DGPS corrections for accurate navigation along the Great Lakes, the Mississippi River and tributaries, the Gulf Coast, and the Eastern and Western coasts of North America. Such radio beacons are not available to consumers traveling in most in-land locations. Current automobile GPS navigation system uses other sensors, such as accelerometers, or speedometers, etc. and plus some sophisticated filtering technology to improve the accuracy (See, e.g., U.S. Patent Number 5,912,635, previously incorporated by reference for all purposes). In addition, many use map-aiding technology as well. However, for handheld device (such as cellular phone) based navigation system, it is impractical to have the handheld devices connected to external sensors. Especially when people use it while they are walking.

Therefore, there is a great need in the art for a navigation system that overcomes the above mentioned obstacles.

III. Summary of the Invention

Accordingly, it is the objective of the invention to provide a real time navigation system for small wireless devices, such as cellular phones.

One aspect of the invention provides an interactive, real-time and distributed navigation system. Accurate navigation information is generated by the server based upon location information provided by the location sensing technology such as EGPS or network based system and the information obtained by interacting with the user. In some embodiments, an ambiguous location of a user, i.e., the location information about a user which is ambiguous for navigation purpose, is determined. A user is then presented with a plurality of candidate locations to chose, wherein the candidate locations are in close proximate of said location. After the user selects one or more of the candidate locations, the user's location is calculated based upon the chosen candidate locations and optionally in combination with the ambiguous location to determine a more accurate location of the user. In some embodiments employing GPS type technology, location of a user is first partially determined based upon GPS signals. In addition, the user interacts with the system and provides related location information, such as the street name, landmarks, etc., observed by the user, to enhance the accuracy of location determination and provide a better navigation quality. The user will interact with the system to enhance the navigation quality. This invention utilizes fully the existing sensor: user's eyes to help to improve the location determination accuracy. For example, when the user requests navigation guidance to the server, the server will compare the direct location measurement with map. Because of the location determination accuracy is normally not good enough, the user's real location may be different from what the location measurement indicates. In order to determine the location of the user, the server will provide a few possible choices, such as several street names, to the user and let user to choose based on what the user sees on the road. Therefore, the navigation system of the invention employs user's eyes are used as additional sensors to the whole system to improve the location determination accuracy and navigation quality.

In some embodiments, the user is presented with several choices of landmarks which can be a building, a street address, a bookstore or any other easily identifiable

objects. The landmarks presented are determined based upon the user's location information (such as GPS or network based location information). The user can select the closest landmark to assist the server to locate the user accurately. Once the location of the user is determined, different kind of digital filtering processes can be used so the interaction with the use is only necessary when the confidence level of the server in determine the user location is below the level previously set. The confidence level can be obtained by comparing the location position after processing and map database.

Another aspect of the invention provides enhanced and simplified dynamic real time navigation system based upon distributed computing and database systems. In some embodiments, geographic map information databases are stored in servers remote from a user. Navigation information is also calculated in servers remote from the user. When the user requests navigation guidance, a request (including destination information) and the location of the user is sent to the remote server. The location of the user can be determined by a third party system or at the device. Or the raw measurements can be sent to the remote server, where the raw measurements will be processed and the location of the user determined. After obtaining the user location, the remote server accesses the geographic map information and generates navigation guidance, which is sent to the user to fulfill the request. In some other embodiments, depending upon the capability of the user device, data storage and navigation calculation load are dynamically distributed between the server and the device. In one particularly preferred embodiment, a user sends a request to navigate from current location (or point A) to point B. A server, after receiving the request (including destination information) and user's location, generates a global navigation route across several small geographic areas. The server then sends information relating to the first small geographic area and navigation guidance information to the user device and the user devices performs navigation in this area. Once the user moves out of the area, the information will be updated by the server either at the request of the user device or initiated by the server based the location of the user.

Another aspect of the invention provides navigation guidance based on the real time traffic condition. The traffic information can be obtained from group of the

navigation service users, by observing their speeds and compare with the street nominal speed limit in the map data base. This traffic information will help the system to determine the best route for its users in real time. At each juncture, the system will dynamically determine the best way to get to the destination based on the traffic information. The best route can be defined based on the user's request, for example, it can be either time or gas consumption that will be minimized.

Another aspect of the invention is that this system will also give directions in a queue ahead of time. This is particularly important for wireless device navigation, because of the small screen size. For example, the server will indicate either by voice or text "you are going to see University Ave. in about 5 minutes (or 500 yards), where you should turn right". In the mean time, if not necessary, the communication link can be stopped to reduce the server traffic.

IV. Brief Description of the Drawings

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

Figure 1 is a schematic showing One Embodiment of the Interactive Real Time Distributed Navigation System- User end.

Item 1 is Mobile wireless devices with position capabilities. For example, the position capability can be built in the device or comes from attached devices or network based solution.

Item 2 is Interactive portion with its users. The interaction with users will be used to improve the position accuracy. Both text or/and voice can be used for interaction.

Item 3 is Ahead of time and real time navigation part. The system will provide navigation guide ahead of time, so the user can use his/her eyes to confirm the navigation guide from the system. Both voice and test will be used for this function as well.

Item 4 is the graphics part. The navigation guide, user location can also be shown on the screen.

Figure 2 is a schematic showing an embodiment of the Interactive Real Time Distributed Navigation System- Architecture A (Internet)

Item 1: Same as Item 1 in Figure 1

Item 2: Wireless carriers. Wireless carriers will provide part of the connectivity for the wireless devices and distributed navigation servers. Some carriers will also have a function to provide the location for the wireless devices. Examples of these wireless carriers include wireless service resellers, wireless ISPs (Internet Service Provider), or satellite wireless carriers.

Item 3: Gateways to Internet connecting the user to the Internet. Gateways can be provided by carriers, ISPs or other providers.

Item 4: Internet

Item 5: Distributed Navigation Servers. These servers will carry street map information and point of interest information. It will also process location specific information, such as traffic information, to help its customers (users) to do real time optimal navigation. It will also carry navigation guide algorithm.

Figure 3 is a schematic showing another embodiment of the Interactive Real Time Distributed Navigation System- Architecture B (Direct links)

Item 1: Same as Item in Figure 1

Item 2: Same as Item 2 in Figure 2.

Item 3: Direct links between carrier and Distributed Navigation Servers. This direct link can be dedicated lines. Or it can means that the Servers are collocated with carrier systems.

Item 4: Distributed Navigation Servers. In addition to the functions mentioned in Item 5 of Figure 2, these servers may include some conversion functions. For example, converting HDML or WML to HTML and vice versa.

Figure 4 is a schematic showing one embodiment of the interactive real time distributed navigation system of the invention.

Figure 5 is a schematic showing a process of Navigation using the interactive real time distributed navigation system of the invention.

V. Detailed Description of the Embodiments

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims.

As will be appreciated by one of skill in the art, the present invention may be embodied as a method, data processing system or program products. Accordingly, the present invention may take the form of navigation systems, navigation methods, navigation devices, navigation software and etc. Software written according to the present invention is to be stored in some form of computer readable medium, such as memory, or CD ROM, or transmitted over a network, and executed by a processor.

A. Interactive Location Determination and Navigation Service

A key component of a navigation system is the determination of the location (or position) of a user. It is intended that the term location (referred to herein as the measurement(2) of a geographic location) includes information related to the position of an object. A location may contain three dimensional information that completely define the exact position of an object. In some embodiments, a location may contain two dimensional information to define an object in a two dimensional space. In some additional embodiments, a location may contain information that is not sufficient to define completely the position of an object. Broadly defined location, as used herein, also may include speed, direction of movement, etc. of an object.

One of skill in the art would appreciate that the format of location information is not critical to some embodiments of the invention. For example, in some embodiments, location information is presented in the format of (x, y), where x and y are two ordinates define the geographic location of an object, i.e., a user.

There are both satellite and terrestrial positioning systems useful for some embodiments of the invention. A location, however, contains various degrees of

inaccuracies. For example, most GPS receivers can provide the location of object within a range of around 50 meters, i.e., an inaccuracy of around 50 meters. There are a number of well know factors that may affect the accuracy of a location determination. For example, weather conditions may affect the accuracy of a GPS location determination. In some embodiments of the invention, a location (measurements), in addition to information defining the position of an object, is also associated with an estimated error and a range. One of skill in the art would appreciate that the error of a location determination may be estimated based upon the characteristics of the positioning device, weather and a number of other factors.

One aspect of the invention provides methods, software and devices for determining whether a location is ambiguous for navigation purposes. Whether or not a location is ambiguous may be dependent upon many factors including, but not limited to:

1) The accuracy associated with the location. In general, the more accurate a location is, the less likely it is ambiguous.

2) Attributes of road network. For example, if one is traveling in a high way in a remote area without any exits, a location associated with error of around 50 meters is not ambiguous for navigation purpose, because the navigation direction will be "going along the highway". In contrast, a location associated with an error of 50 meters is clearly ambiguous if the location is within a business district of a downtown where street blocks are less than 10 meters away. In some embodiments of the invention, whether a location is ambiguous is also dependent upon traffic regulations. For example, if there are only two roads (Road A and B) within the range of a location (location+/-error), the user is traveling at a speed of 55-80 miles/hr and road A has speed limit of 25 miles/hr, the location is unambiguous for the purpose of navigation because the user's location can be determined to be in Road B with high confidence in general.

3) Recent traveling history may also be a relevant factor.

4) Map accuracy.

Ambiguous locations present a challenge to a navigation system because good navigation direction can not be directly generated using an ambiguous location. To

overcome this problem, one aspect of the invention provides methods, software and devices for interactively determining the location of a user. In some embodiments, one a location is determined to be ambiguous (Figure 5, 2). A map database is searched, using the ambiguous location and the associated error, for candidate locations (usually some visible landmarks, such as a building, a hospital, a hotel, a street intersection, street names, etc.). One of skill in the art would appreciate that various types of database structures can be useful for at least some embodiments of the invention. Many map databases, search methods, algorithms, software are either well known or commercially available.

Once a list of candidate locations is generated, if the list is too large and inappropriate for presenting to the user, the list may be consolidated (Figure 5, 4). For example, a list of 400 candidate locations (occasionally referred to as candidates) is too large for display in the LCD screen of a typical cellular phone, without scrolling. One of skill in the art would appreciate that there are many ways to consolidate such a list of candidate locations. Optionally, the list of candidate locations may be ranked based upon the probability of their being the closest to the user (or the actual location)(Figure 5, 5). The list of candidate location is presented to a user (Figure 5, 7 and 8) and the user can select the one that is closest to the user. The user's selection is then used to calculate the actual location of the user (9, 10). In some embodiments, the user's location is calculated as the selected candidate location. In some other embodiments, the user's location is the middle of the ambiguous location and the selected candidate location. One of skill in the art would appreciate that other methods of calculating the actual location is also within the scope of the invention.

One of skill in the art would also appreciate that the user may also be asked to select candidate locations according to criteria other then closest distance. For instance, a user may be asked to select the candidate location in a specific direction, such as "selecting the candidate location direct in front of you." It is also apparent to one of skill in the art that the user may also be asked to select multiple candidate locations in response to a question such as "Select candidate locations in front of you."

The process for interactive determination of a location may be repeated a number of times to obtain unambiguous locations (see, figure 5). The process may be performed in a single device that contains at least one processor and a memory. In some preferred embodiments, the process is executed in a device that contains a processor, a main memory, a hard drive and a data storage space for storing a map database. Code executing the process described above is loaded from the hard drive into the memory and executed by the processor. As it is apparent to one of skill in the art, other data processing architectures may also be suitable for some embodiments of the invention.

In some most preferred embodiments, the interactive real time determination of a location and navigation service is performed in a distributed system containing a client, a remote server and a wireless communication between the two (Figure 4 and 5).

B. Distributed Navigation Service

One aspect of the invention provides distributed navigation services which may be used in conjunction with the interactive real time navigation described above. In some embodiments, this new navigation architecture (Figure 2 and 3) employs wireless and communication (Internet) infrastructure and server technology. In particularly preferred embodiments, most navigation data storage, maintenance, retrieval and real time processing are conducted at the server level. The full navigation workload are distributed among servers, devices, depending the locations of the users, capability of the wireless devices and real time situation at the user end.

In another aspect of the invention, the data storage and computation workloads are distributed between servers and local devices. In some embodiments, if the local device has an excessive memory and computation power, servers can download more information into the device and give more autonomous function to the device. That is the reason it is called distributed navigation system.

In yet another aspect of the invention, the navigation system of the invention provides real time navigation information. Specifically, in some embodiments, the navigation system is a dynamic system (unlike map or many driving directions

provided by Internet portals, such as YAHOO, MAPQUEST, etc), it will provide real time turn by turn navigation guidance. It will utilize voice, text and graphics in aiding its users to navigate. It is also an interactive navigation system. Given that none of the location technology can pinpoint the user location 100% and street condition may change, it is possible that the user get lost because of the user location error or the new street change. The new interactive navigation system utilize the users vision and ask for the user input (what he/she saw) and compare with the options generated by the server based on the map data base to improve the location accuracy and hence improve the navigation accuracy. Basically it is an intelligent system; it learns real time about the location by including its user in the loop.

This navigation system will derive the real time (or close to real time) traffic information based on its user group (location, speed, and time) information. The traffic information will be used in determining the optimal route (minimum time, or minimum gas as desired by its user) for the user to get to his/her destination. This optimal routing will be dynamic as well. It is not necessary the one the system set when its user first request the navigation aid. The system will dynamically determine the route real time based on the real time traffic and weather situation at each conjuncture he/she meets. Of course if third party traffic information is available, it can also utilize that as well.

Wireless devices can be any mobile devices with capability of communicating to other places. The locations of these devices are available, through its own function or carrier's function or combined function of the device and carriers. For example, the wireless device can use GPS (Global Position System) to determine its location, or it can use carrier network based method to determine its location. This patent does not constraint to any particular location determination technology. The wireless devices can be any portable devices with wireless communication capability. For example, it can be cellular phones, satellite phone, Personal Digital Assistance and mobile computers, etc.

The wireless device does not need to carry map information. But it can carry minimum amount of map information, depending on the original design of these devices, for example its storage size.

If the wireless device has voice function, it can tell the user certain location specific commands or suggestions, for example, it can tell the customer turn by turn driving or walking navigation guide. It can also take the voice message from the customer to the distributed navigation server, which can process the request and provide corresponding suggestions or guidance.

The wireless device can also show graphically the navigation information on the display of the device or on a display connected to the device.

Wireless carriers will provide part of the connectivity for the wireless devices and distributed navigation servers. Examples of these wireless carriers are wireless service resellers, wireless ISPs (Internet Service Provider), or satellite wireless carriers. Wireless carriers or third parties may provide the location capability for wireless devices.

The system will need some kind of link for the distributed navigation servers and carriers. They can either be through Internet or direct links (For example, T1, Frame Relay etc or collocated at the carrier site linked by LAN). The direct link architecture is applicable where Internet infrastructure is not well established or fast response is desired for user navigation or other location specific information services.

The Distributed Navigation Server will store the street map and other location specific information. When requested by the wireless user or any other authorized user, the server will use the user's location information and process the information, then provide corresponding guide to the user. The user will get the guide through voice or display (for example, text or graphics). These servers also distribute certain tasks between the server and the wireless devices, depending on what kind of the devices the users use. For example, for a less powerful device, the server will carry major tasks, while for quite powerful devices, the server may let the devices do certain localizable tasks, for example, storing some location information for quick response. These Distributed Navigation Servers can be centralized, in case of limited number of users. In most cases, they will be distributed in different regions to respond to local request faster.

Figure 4 shows one embodiment of the interactive navigation system of the invention. The navigation system comprises a wireless device (1, such as a PDA, Cell

Phone, or any wireless device with location determining capability) and a server (7) which contains at least one central process unit and a map database. This location information may be ambiguous due to a number of factors discussed above. A location is ambiguous if navigation directions can not be generated. For example, if the user is driving in a downtown area with many close streets, a GPS location with +/- 50 meters is not adequate to give turn by turn direction in some embodiments of the invention. The GPS location information is thus considered as ambiguous in such embodiments. In other situations, a GPS location with +/- 50 meters is adequate for navigation purpose. For example, if a user is driving in a highway in a remote area without any close exits, the GPS location is sufficient for calculating further navigation directions for the user. In such a situation, the GPS location is not ambiguous in these embodiments.

The location information is transmitted to the server which determines whether the location information is ambiguous. If it is ambiguous, the server will search the map database to locate several candidate locations (or candidates or candidate landmarks) around the ambiguous location (6). The candidate locations can be a street address, a high building, a gas station or other landmarks. The candidate locations (5) are transmitted to the wireless device (1) for display. The user can choose the candidate location that is closest to the user. The user's chosen location is then sent to the server. The server can determine, according to the most recent user/device location information and the closest candidate location, the user's actual location. This process may be repeated to enhance the accuracy of the user location measurements. One the location measurements satisfy the requirement of further navigation. Further navigation information is transmitted to the user.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to

best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A method for determining the location of a user comprising:

a) determining an ambiguous location of a user, wherein said location is ambiguous for navigation;

b) presenting to said user a plurality of candidate locations, wherein said candidate locations are in close proximate of said location;

c) receiving from said user's chosen location from said plurality of candidate locations;

d) adjusting said location according to said chosen location.

2. The method of claim 1 wherein said chosen location is the most possible location among said plurality of said candidate locations of said user.

3. The method of claim 1 wherein said step of determining an ambiguous location is conducted in a device wherein said device comprises a satellite based location determination system.

4. The method of claim 3 wherein said satellite based location determination system is a global positioning system.

5. The method of claim 1 wherein said step of determining an ambiguous location is determined using a terrestrial based location determination system.

6. The method of claim 1 wherein said method is conducted in a single device.

7. The method of claim 1 wherein said step of determining an ambiguous location further comprises transmitting location information to a server via wireless transmission.

8. The method of claim 4 wherein said step of presenting further comprises the steps of:

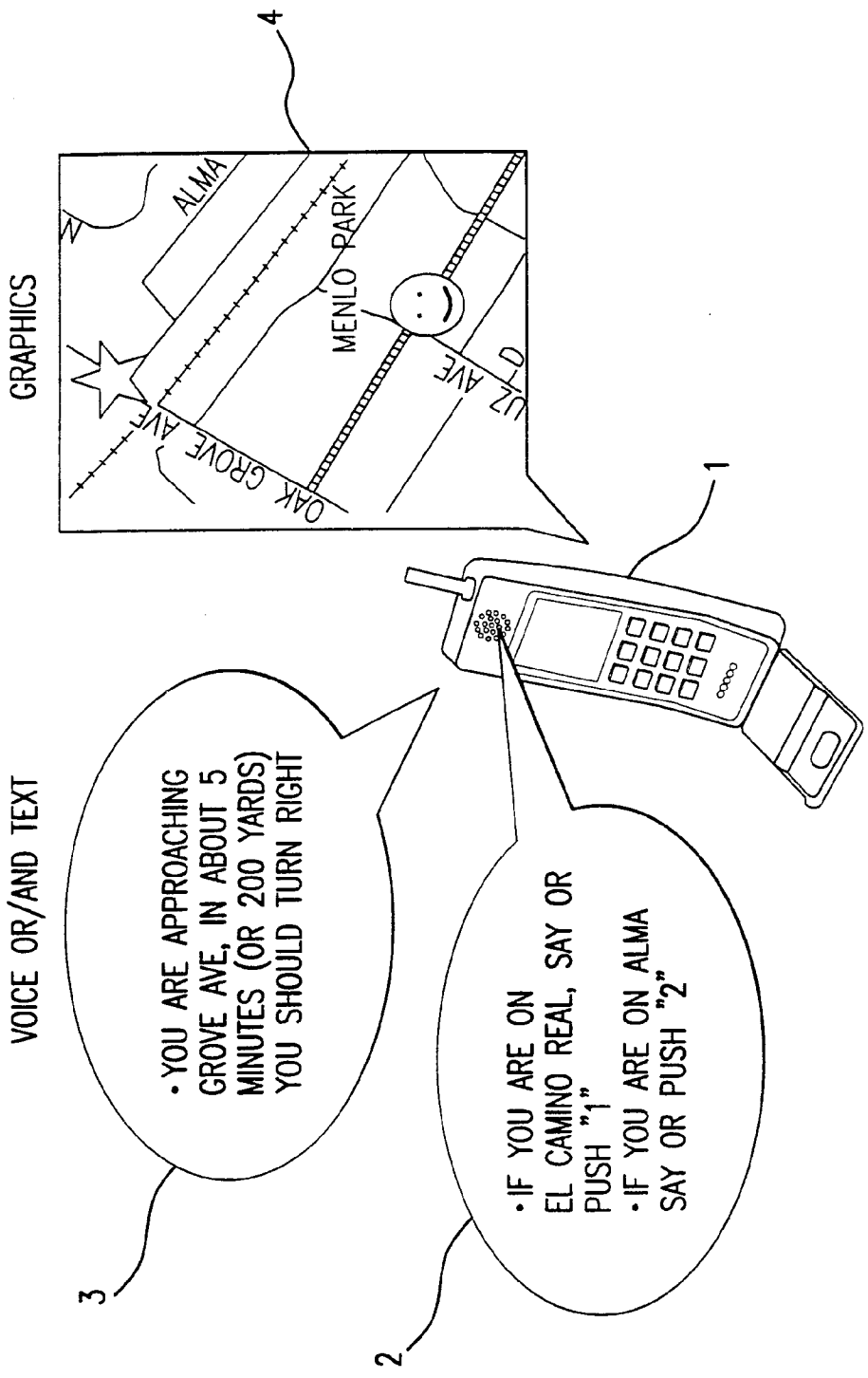
a) calculating said plurality of candidate locations in a single device or a remote server;

ranking said plurality of candidate locations; and

transmitting said plurality of candidate locations to device.

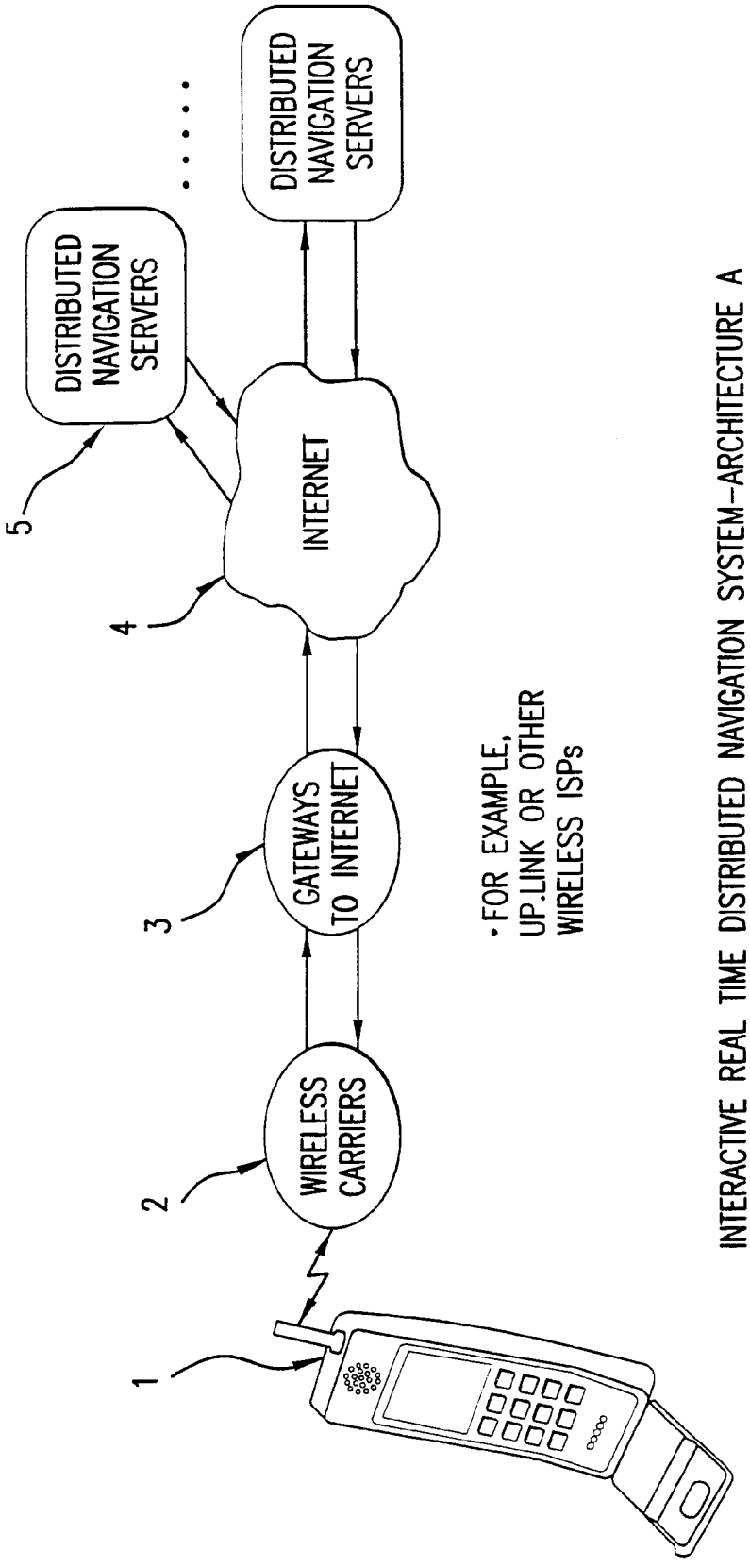
9. The method of claim 8 wherein said device is a cellular phone.

10. The method of claim 9 wherein said device is a PDA.



INTERACTIVE REAL TIME DISTRIBUTED NAVIGATION SYSTEM–USER END FUNCTIONS

FIG. 1



INTERACTIVE REAL TIME DISTRIBUTED NAVIGATION SYSTEM–ARCHITECTURE A

FIG.2

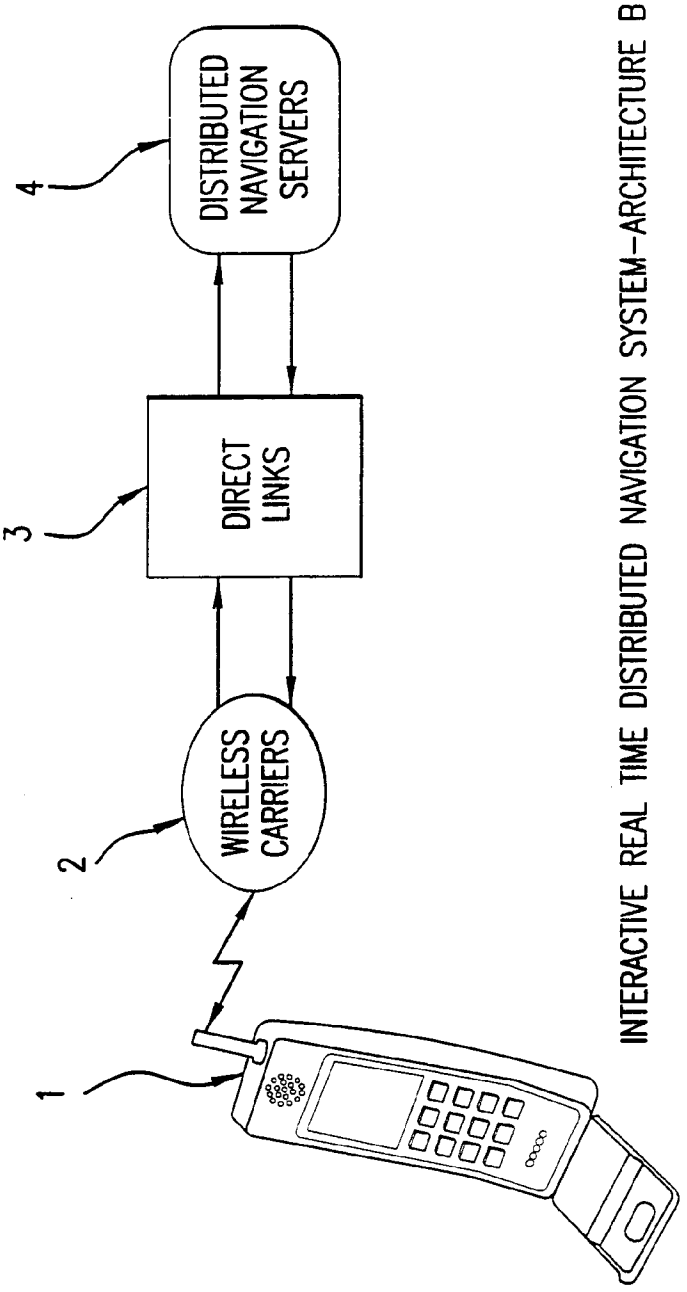
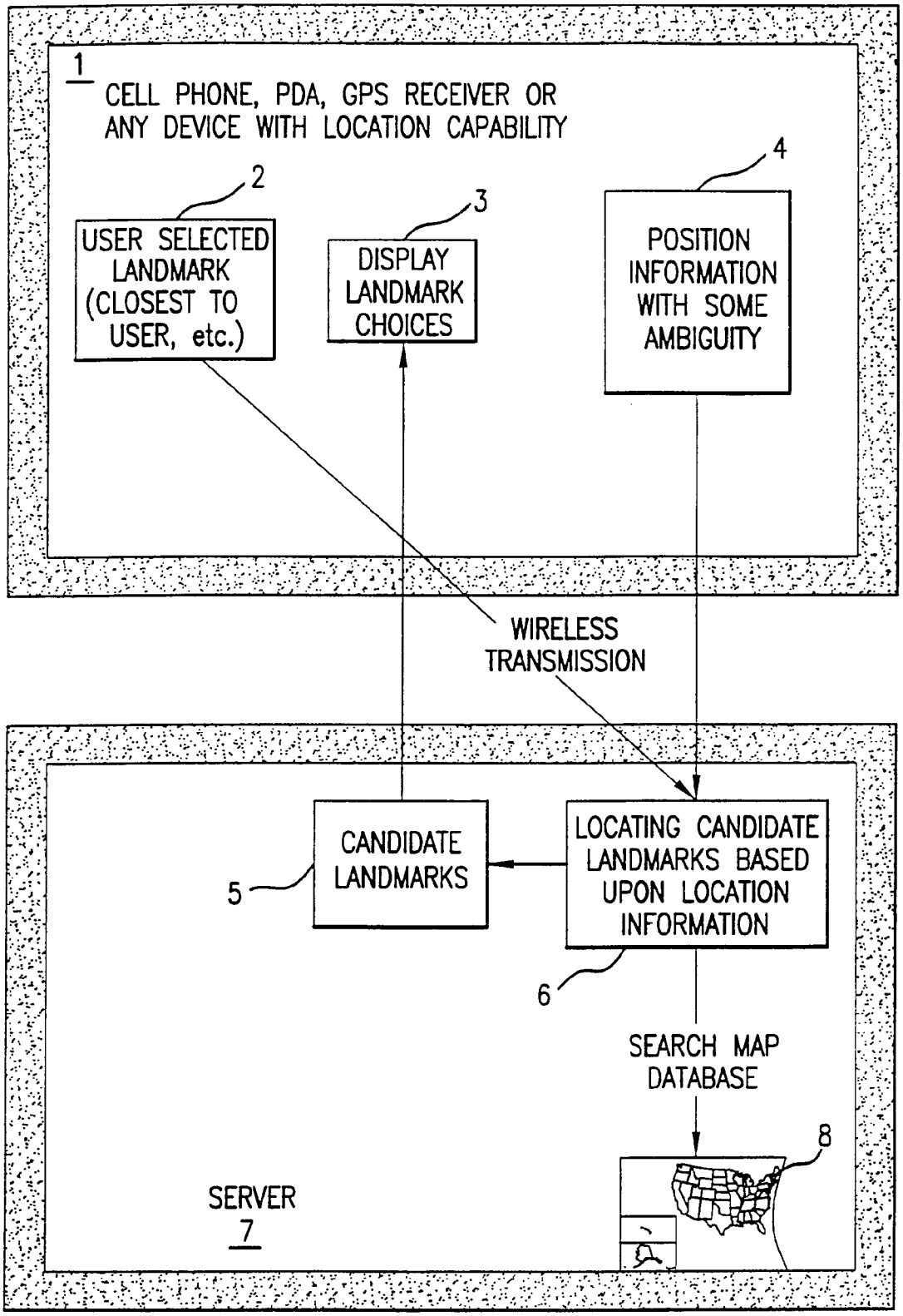
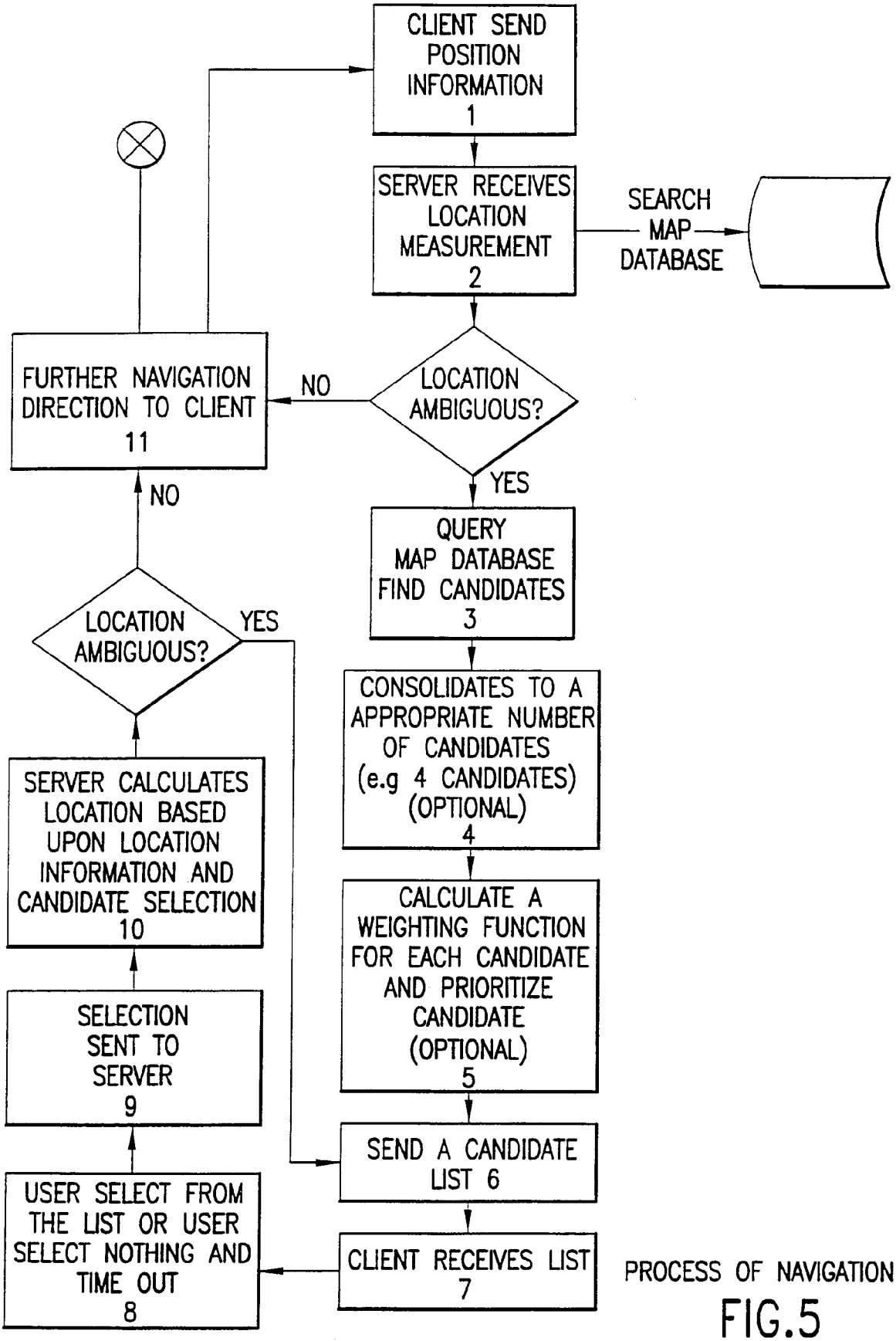

4
DISTRIBUTED NAVIGATION SERVERS
3
DIRECT LINKS
2
WIRELESS CARRIERS
1
• WIRELESS PHONES OR PDAs WITH POSITION CAPABILITY
INTERACTIVE REAL TIME DISTRIBUTED NAVIGATION SYSTEM–ARCHITECTURE B

FIG.3



AN INTERACTIVE REAL TIME DISTRIBUTED NAVIGATION SYSTEM

FIG.4



PROCESS OF NAVIGATION

FIG.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/26921

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G01C 21/34

US CL :701/207, 211, 213; 342/357.06, 451; 455/456

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 701/200, 202, 207, 208, 209, 210, 211, 213; 342/357.01, 357.06, 357.09, 357.17, 358, 450, 451; 455/414, 456, 457

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P --- Y, P	US 6,029,069 A (TAKAKI) 22 February 2000, fig. 3 and columns 5-6.	1-9 --- 10
Y	US 5,938,721 A (DUSSELL et al) 17 August 1999, fig.1.	10
Y	US 5,528,248 A (STEINER et al) 18 June 1996, fig. 2.	10
A, P	US 6,021,371 A (FULTZ) 01 February 2000, see the entire document.	1-10
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[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search 17 DECEMBER 2000	Date of mailing of the international search report 12 JAN 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer GARY CHIN Diane Smith for Telephone No. (703) 308-1113

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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